VLBI TRACKING OF PLANETARY PROBES AS A MISSION TOOL AND SCIENTIFIC EXPERIMENT

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Very Long Baseline Interferometry (VLBI) technique offers an unrivalled angular resolution reaching fractions of a milliarcsecond (mas) in studying structures and defining positions of celestial radio sources. Developed originally for astrophysical studies of natural sources of radio emission, VLBI entered the field of space flight science and engineering as an efficient tool for ultra-precise determination of coordinates and parameters of motion of planetary probes and other spacecraft. This application of the technique was introduced in the 1970s (Thornton and Border 2003). VLBI tracking was demonstrated for the VEGA (Venus – Halley Comet) mission in the mid 1980s (Preston et al. 1986, Sagdeev et al. 1992). Recently, the VLBI technique was applied to tracking of the Huygens Probe during its parachute descent in the atmosphere of Titan and on the planet's surface (Lebreton et al. 2005).

In this presentation we review VLBI tracking methodology using the Huygens VLBI experiment as an example. This experiment required development of the technique to the limit defined by the present day technology. It necessitated development of a novel software VLBI correlator enabling sub-Hz spectral resolution and use of the disk-based direct-access VLBI recording systems. Data processing of the Huygens VLBI tracking required introduction of a relativistic model in the near-field interferometry – a modification of the technique seldom used in the earlier VLBI spacecraft tracking applications. VLBI tracking of the Huygens Probe resulted in the sub-mas accuracy of determination of the transmitter position that corresponds to the random error of about 1 km. The Huygens VLBI processing also enabled independent verification of Doppler measurements of the winds in the atmosphere of Titan conducted by the Doppler Wind Experiment (Bird et al. 2005).

Future developments of VLBI tracking of planetary probes will be discussed in the light of their synergy with the progress of radio astronomy technologies. In the near future, VLBI will be able to detect radio transmission of distant spacecraft at Ka-band (32 GHz), a considerable improvement in terms of angular resolution comparing to standard nowadays S-band (2.3 GHz) and X-band (8.4 GHz) radio links. Large collecting areas of the prospective VLBI antennas combined with a wider band VLBI data streams (corresponding to data rates 1 Gbps and higher) will make it possible to use weak natural background sources as "anchors" for spacecraft tracking virtually anywhere on the celestial sphere. We will briefly discuss these perspectives emphasising both scientific and engineering aspects of the experimental technique.

References

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